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NUTRITION AND PUBLIC HEALTH WITH SPECIAL REFERENCE TO VITAMINES.[1]

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Notwithstanding the fact that my first biological interest was in relation to the subject of nutrition, my earlier experiments were made on myself and were discontinued as soon as my curiosity was satisfied, and I have had occasion to work out, in a scientific manner, only small details of this vast subject. While serving with the Division of Food and Nutrition, Medical Department, U. S. Army, I was impressed with the wide differences of opinion that exist in

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the public mind, and especially among the medical profession, on this subject, and since January 1, 1919, with the assistance of ten students, I have devoted nearly all of my time to investigation in this field, the results of which are being published in the *Journal of Biological Chemistry*. Owing to the fact that the changed economic conditions due to the war have brought about some changes in dietary habits, the effects of which may not be thoroughly appreciated until some years have passed, a compilation of some of the literature and discussion of some of the problems may not be out of place at this time. Since vitamine studies are receiving considerable attention just now, attention will be directed especially to them throughout most of this paper. Other subjects will be treated more briefly, not because they are less important, but because they are better understood.

EFFECT OF FUEL VALUE OF DIET ON BODY WEIGHT. Benedict, Miles, Roth and Smith have so thoroughly investigated the effects of a restricted diet (about 2 ounces protein and 2000 calories per ration) that further comment seems unnecessary. Similar restrictions of diet have been voluntarily or involuntarily made by large numbers of persons during the war. One common conclusion from these experiments may be emphasized here, since I have heard it repeatedly denied by persons who had no reliable information on the subject, and that is that the body weight is just as much dependent on the calorific value of the food in man as in animals. Perhaps many persons partake of a low calorific diet in the presence of an abundance of food, owing to various factors that reduce the appetite. In animal experiments a diet that is inadequate in regard to some constituent reduces the appetite. This has been especially noticed in experiments in which one or more of the amino-acids or vitamines was deficient in quantity. Animals on a vitamine-free diet finally refuse food entirely. This factor may be suggested as a possible danger in so-called low protein diets.

As early as 1887, Hirschfeld advocated a low-protein diet and the same ideas have been proposed by many scientific and unscientific propagandists since that date. In 1898, while a university student, subject to compulsory physical exercise, I restricted my diet for three months in regard to the quantity of animal foods taken. My weight dropped to 70 pounds and my skin became rough, the hair on my body and face standing at right angles to the skin surface. At the end of this experiment I partook of a liberal diet, including fresh meat and vegetables, eggs, milk, beef fat, cod-liver oil, raw bone-marrow and malt extract, and at the end of one year my weight was 140 pounds, showing a gain of 3 ounces per day. In order to distinguish between quality and quantity of the diet I made another experiment in 1912. After having maintained a fairly constant weight under certain conditions for several years, and without consciously disturbing those conditions, I added about

2 ounces of cottonseed oil per day to my diet and gained 3 ounces per day for eighty days. Since the oil was drunk after meals it did not interfere directly with my appetite, and since it is not known to contain a vitamine or other growth-producing substance, it probably acted purely through its calorific value or was stored, together with water, as adipose tissue. Since fat does not cause excessive water storage, as is the case with carbohydrate, the increase of about 15 pounds in weight cannot be attributed to water storage alone.

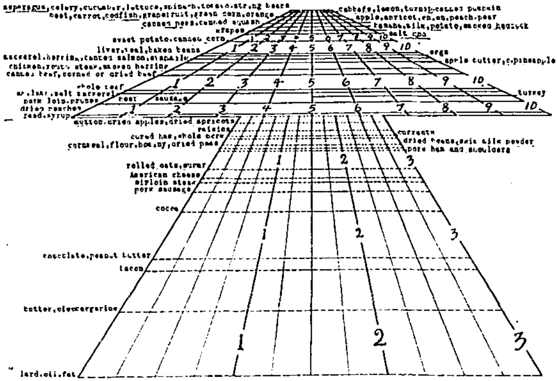

Chart for rapid calculation of fuel value of diet. The calorific value of any food may be calculated from its weight in pounds by finding the name of the food in the chart and the number corresponding to its weight on the line containing its name. Apply a millimeter tape to the scale on the chart and each millimeter represents 100 calories. In the upper part of the chart the scale reads in pounds from one to ten. In the lower part of the chart the scale reads in pounds from one to three and further divisions signify halves and quarters of a pound and the breaks in the horizontal lines signify ounces. Foods of the same calorific value are on the same line and their weights may be added together before using the chart. In order to use the chart for simultaneous multiplication and addition, prepare the list of foods in pounds and measure the pound scale of each successively with the millimeter tape, commencing each measurement on the tape at the end of the preceding one. The final figure on the tape with two ciphers added represents the total number of calories of the entire list of foods.

Although a restricted diet has been advocated by Horace Fletcher, Chittenden, and more recently by Hindhede, these propagandists seem to be in the minority. Another point of view is illustrated by the excuse a slave gave for stealing a chicken: "Nigger meat's wurf mor'n chicken meat." There are some uses of a restricted diet, however, but the difficulty lies in enforcing the dietary rules. It is said that in the treatment of obesity at Carlsbad the patients were served very small portions at high prices *à la carte.*

In economical rationing a rapid and inexpensive method of calculation of fuel value of food is desirable. By means of the chart shown, simultaneous multiplication and addition is performed in calculation of the calorific value of a list of foods. The time required is chiefly used in finding the name of the food on the chart, and hence speed increases with practice. The first time I used this chart the percentage error and the number of minutes required were carefully noted. The food used by the 9th Engineers in one week was used in the test. It required five minutes to calculate the calorific value of this food with the chart, and the error was 5 per cent. By taking more time to read the chart, or by using a chart on a larger scale, greater accuracy may be obtained in the calculation, but since the accuracy of the data may not exceed 5 per cent., greater accuracy in calculation may not be desired.

REACTION AND BACTERIOLOGY OF THE ALIMENTARY TRACT. The reaction of the alimentary tract is important in relation to the character of the hydrolysis of the food, either due to digestive juices or bacteria. The saliva in the closed mouth is about neutral. The gastric juice is about one-tenth normal hydrochloric acid and the exact hydrogen ion concentration of the stomach contents depends on that of the food and the relative quantity of gastric juice that has been secreted (as well as the degree of mixing.) McClendon and Sharp have shown that with the occasional exception of fresh milk, both raw and cooked foods are slightly acid. It should be noted that in the paper by McClendon and Sharp the first table (quoted from Clark and Lubs) should be omitted, since acid or alkali had been added to the food juices in many cases. The low acidity of the contents of the infant's stomach after feeding is not so much due to lower acidity of the gastric juice as to the diet of fresh milk, and possibly to the small quantity of gastric juice secreted. It was shown by McClendon, Myers, Culligan and Gydesen that the small intestine is slightly acid in young and adult carnivora and young herbivora. In adult herbivora, however, the duodenum is usually slightly acid, but this passes over to a slightly alkaline reaction somewhere in the small intestine. The reaction of the rabbit's intestine could be changed from alkaline to acid by flooding it with soluble carbohydrate, as by adding lactose to the diet or feeding carrots exclusively.

According to Metchnikoff the presence of acid-producing bacteria in the intestine inhibits the growth of putrefactive forms. Torrey has shown that flooding the intestine with soluble carbohydrate, especially lactose, increases the ratio of the acid-producing to the putrefactive bacteria. This is in line with the fact that the ingestion of soluble carbohydrate changes the reaction of the rabbit's intestine from alkaline to acid. Perhaps it is the acid reaction of the intestinal contents that inhibits the growth of putrefactive bacteria. Exercise, by causing more rapid absorption of water from the intestine, may decrease the growth of bacteria, whereas in diarrhea the increased fluidity increases bacterial growth.

Besides the common bacteria of the intestine just mentioned, that are always present, and whose relative numbers depend on the soluble carbohydrates present, other bacteria that are normally absent appear as infections, as, for example, the typhoid and paratyphoid group. It seems possible, also, that other less virulent, unidentified bacteria may play a part in altering the normal conditions of nutrition.

COOKING. In *The Complete Cook*, 1805, which is the revised and corrected edition of *The Frugal Housewife*, the following sentence may be found in the preface: "The chief excellence of all cookery consists in a perfect acquaintance with the making of gravies and sauces." That is not the aspect of cooking to which reference will be made. The natural flavors of foods with the addition of salt, which is a necessary ingredient of the diet, should be sufficiently attractive to the hungry man. The necessity of cooking lies in two circumstances: (1) it is necessary to gelatinize the starch in starchy foods in order to make it utilizable and (2) it is desirable to kill certain pathogenic organisms or destroy bacterial toxins when present. Most starches gelatinize in water of 70° C. in a few moments, and prolonged cooking is only necessary in case the food is so dry that prolonged soaking is necessary to wet it (and the heat merely shortens the time necessary to soak it). Cooking softens food so that it is easier to chew, but that may not be wholly desirable. If it is desired to gelatinize collagen a high temperature or prolonged duration is necessary, but gelatin is too deficient a protein to be much sought after.

Many persons who would not eat a rare steak see no necessity in cooking canned goods. From the standpoint of danger from bacterial agencies, however, it is more necessary to sterilize preserved foods than fresh ones. Many cases of botulism are due to eating canned foods or tasting them to see whether they are spoiled, and it is stated that cooking destroyes the toxin of Bacillus botulinus. Since cooking reduces the vitamine content of foods any unnecessary cooking is to be discouraged. Fresh foods if kept clean should be eaten raw or rare, whereas preserved foods, as a rule, should be cooked. Pork and fish should be sterilized because they are liable to contain parasites that escape detection. Mixtures of meat and vegetables should not be allowed to remain long uncooked, because numerous spore-bearing bacilli on the vegetables multiply rapidly in the meat juices.

Many persons object to visible fat in cooked food; in fact, some cooks remove fat from the surface of soup with blotting paper. Fried foods are said to upset delicate stomachs, and this has been attributed to the action of heat in setting free fatty acids. It has been shown, however, by the War Committee of the Royal Society that free fatty acids in relatively large quantities may be eaten without disagreeable effects. Perhaps the irritant action of some fried foods may be due to the formation of acrolein. Since this occurs only in case the temperature is raised to 300° C., there is no necessity for it. The fat of all foods should be eaten as an economical measure.

Food Preservation. The most ancient and widely used method of food preservation is by desiccation. The seeds of plants are usually desiccated before they are gathered for food. The desiccation of root vegetables was practised by various savage tribes and the drying of meat and fish was perhaps as common a practice. Hawk calls attention to the fact that dehydrated vegetables when soaked up again hold their water much less tenaciously than fresh vegetables do. This has been known as a characteristic difference between live and dead tissue, and the living state is associated with electrical polarization of the cell surfaces, which would partially explain the holding of water. In fact, it is the tenacity with which foods hold to water that adds largely to the cost of dried foods. In the drying of prunes, decomposition usually takes place unless the prunes are first dipped in an alkaline solution, so as to make them permeable to water. In the desiccation of tissue for biochemical analyses it has long been known that decomposition of phosphatides and oxidation of unsaturated fatty acids occurs if the moist or dried tissue is exposed to air, and similar decomposition must occur in dried foods.

Various forms of pickling and preserving in which the addition of salt or sugar occurs is similar to drying, in that the antiseptic action of salt and sugar is partially due to their dehydrating effect on bacteria. The use of other antiseptics is so limited as to be of minor importance.

The process of canning might be considered next to refrigeration in excellence as a method of preserving food, but unfortunately, complete sterilization and exclusion of air does not always occur. In the canning of milk, partial desiccation is also performed.

In the process of cold storage, vegetables and fruits remain alive, and it is claimed that fish may be kept alive in cold storage by the Pictet process. The growth of penicillium on beef in cold storage hastens ripening and the beef does not become toxic until the taste changes to musty or bitter. Beef is the best meat for cold storage on account of its large size and low water content and mechanical density, which inhibit the penetration of microörganisms. Cold storage is the only method of food preservation that maintains the total vitamine content.

Proteins, Fats, Carbohydrates, Salts and Water. The protein factor in nutrition has been so exhaustively treated by Osborne and Mendel and others that it cannot be reviewed here. A a general rule animal proteins are more complete in amino-acid content than are those of vegetable origin. According to Goldberger, Wheeler and Sydenstriker, families in which pellagra occurred consumed 3 ounces of protein per man per day, but only 25 per cent. of it was animal protein. Since a nitrogen balance may be maintained in skinny individuals on less than 3 ounces of protein per day, we may assume that 3 ounces is sufficient, provided it is all animal protein; but that in case of mixed proteins, and in the absence of more definite knowledge, it is not wise to make a special effort to limit the protein intake. Under modern conditions there seems to be no defence for vegetarianism. Clark finds a high protein diet increases the rate of healing of wounds. It is also useful in case of profuse pus formation to replace the lost protein.

In addition to the fact that some fats contain vitamines, fats are necessary in the diet to decrease its bulk. In a diet of 3000 calories it would require 10 pounds of potatoes or other vegetables or fruits for the three meals, and if we include the saliva and other fluid swallowed and the gastric juice secreted the stomach would receive a load of about 8 pounds per meal (not all at once, however). Hardtack would be less bulky, but would increase salivation and thirst. The Interallied Scientific Food Commission fixed the minimum fat ration at 75 grams.

So far as investigations have progressed, muscular work depends on a supply of carbohydrate (compare Anderson and Lusk). In the absence of carbohydrate, fat is incompletely oxidized (for heat production) and yields products that may be toxic. Both man and the dog may live for considerable periods without carbohydrate in the food and probably depend for muscular energy on the carbohydrate radicle of phosphatides and glycoproteins and especially on the synthesis of glucose from glycerin and deaminized amino-acids; but there seems to be no advantage in such a diet. The flooding of the intestine with soluble carbohydrate retards putrefaction of proteins.

Salts are necessary, but since all factors causing their excretion have not been thoroughly investigated the minimum requirement is uncertain. Sodium chloride should be added to food, but it seems probable that the other salts are present in a mixed diet in sufficient quantity. Since milk and fresh vegetables that are rich in salts are also rich in vitamines that cause relative retention of salts, all that can be said is that milk and fresh vegetables are advantageous, and we are not justified in substituting an inorganic salt mixture for them. No harm can arise, however, in the addition of such a mixture to an apparently adequate diet.

The necessity of water in the diet needs no comment, and Hawk and his collaborators have shown that no ill-effects follow water-drinking at meals. The salt content of drinking water is usually insignificant, and the arguments for lithia water have been shown to be fallacious.

VITAMINES. Owing to the fact that differences of opinion exist among investigators as to the number of vitamines, the classification made by the British Committee on Accessory Food Factors will be followed. Hopkins studied "Accessory factors in food." Funk called these vitamines, and McCollum and Kennedy claim there are only two vitamines, which they call fat-soluble-A and water-soluble-B. Drummond refers to the antiscorbutic factor as water-soluble-C. McCollum and Kennedy's A-factor is also called fat-soluble or antirachitic vitamine, and their B-factor is called antineuritic vitamine, whereas Drummond's C-factor is usually called antiscorbutic vitamine.

The fat-soluble or antirachitic vitamine is very abundant in yellow fats of animal origin. It is deficient in pig fat because the pig eats few leaves, and in hydrogenated or hardened fats and free fatty acids because it is destroyed by the heat and chemical agents used in manufacture. It is deficient in vegetable fats except perhaps in peanut oil. It is synthesized in green leaves, and carnivorous animals depend for their supply on the bodies of grazing animals in which it has been extracted from the green leaves eaten and stored in the body fats. It is abundant in the germ of seeds, especially yellow seeds but deficient in degerminated cereals. It is present in potatoes, carrots and bananas, being most abundant in the yellow colored roots (carrots and sweet potatoes). According to McCollum the milk of cows is richer in fat-soluble-A when more is present in the cow's food. According to Osborne and Mendel, 1916, this vitamine is not destroyed in butter fat by storage for a year. According to Drummond, fat-soluble-A is not carotin.

The antineuritic vitamine seems to be most concentrated in the seeds of plants and eggs of animals. In cereals it is present in the germ but absent in the endosperm and bran (unless the bran contains the germ. It is abundant in yeast and in animal gland tissue, but muscle tissue and milk do not contain an oversupply. Both leaf and root vegetables and fruits contain it in small amounts. Cooking reduces the quantity of this vitamine. As first observed by Frazier and Stanton the content of food products from the same source in this vitamine runs parallel to the phosphorus content. According to Voegtlin and Myers, both antineuritic and fat-soluble vitamines of wheat and corn products run parallel to the phosphorus content.

The antiscorbutic vitamine seems to be present in all living tissue and fresh food, and is especially abundant in acid fruits, tomatoes, cabbage and turnips. It is more or less abundant in all fresh, raw vegetables. It is very sensitive to alkali, heat, desiccation and storage at ordinary temperatures, and hence is deficient in cereals and dried or canned meat and vegetables, except canned tomatoes. The acid in tomatoes and fruits seems to protect it during the heating and it is useful to class tomatoes with fruits, as is done by British writers. It is present in milk in small amounts. Dutcher has shown that young guinea-pigs grow better and are healthier on milk from a cow on green feed than of a cow on dry feed. Scurvy developed very quickly on winter milk, but did not develop (in the same length of time) on summer milk. The milk was skimmed in both cases to prevent diarrhea. This indicates that the antiscorbutic vitamine in milk depends on that in the cows' feed, and may explain why some breast-fed babies have scurvy if the food of the mother is deficient in antiscorbutics.

VITAMINE REQUIREMENTS AND DEFICIENCY DISEASES. Since the composition of vitamines is unknown and their distribution among foodstuffs is known only in a general way, it is not yet possible to work out the vitamine requirements with even as much certainty as has been done in the case of food constituents of known composition. Experiments on animals and observations on man indicate that vitamine deficiency manifests itself more slowly the longer the average life (in different species) and the more mature the individual (in the same species). It is also necessary to know that the individual has been getting an adequate supply of vitamines before the beginning of the experiment in order to determine the duration of vitamine deficiency that it can stand. Even with this precaution, variations in results may be obtained owing to lack of knowledge of the degree of vitamine deficiency in the food. At present the vitamine content of foods can only be determined by the quantity of the food necessary to prevent or cure deficiency diseases. Hence the vitamine requirement may be estimated only in terms of the proportion of vitamine-containing foods required in the diet.

That the deficiency diseases are due to lack of vitamines can be determined only by the method of exclusion. Almost every imaginable cause has been attributed to the deficiency diseases, and some causes have been proposed that it is impossible for me to imagine. For instance, scurvy has been attributed to lack of ionization of the salts in the food due to staleness, and it is impossible for me to imagine a lack of ionization of these salts in food that has been eaten, and certainly food will not hurt you if you do not eat it. Scurvy has been attributed to an acid-forming diet, but McClendon, Cole, Engstrand and Middlekauff have shown that this factor is not responsible for scurvy. The germ theory of these diseases will probably be popular for a long time, since bacteria are always present, waiting for an opportunity to hasten the death of a weakened individual. It is therefore useful for purposes of discussion to include among deficiency diseases those that have been cured in the presence of a vitamin-rich diet and have not been cured in the absence of such a diet. We will consider deficiency diseases of infants and adults.

Rickets is perhaps the most common deficiency disease, frequently occurring in breast-fed infants. To quote a book written before Funk's ideas of vitamines were generally known, Miller states that, without doubt, rickets is to be regarded as a dietetic disease, and considers deficiency of butter fat as the most constant and potent cause. In treatment, among other things, he recommends milk, cream, butter, egg yolk and cod-liver oil. These fats are especially rich in the antirachitic vitamine. Since the bones are softened in rickets the child may not be able to take proper exercise or go out into the fresh air, hence the view that rickets is due to lack of exercise or fresh air. The mother's milk might be sufficient in antirachitic vitamine, and yet the child may have rickets, due to the fact that it was weaned too soon. The Fijians, who included some of the finest specimens of physical development in the human race, nursed their infants for three years, and as the mother's milk became deficient in quantity, supplemented it with bananas. Rarely a mother in this country nurses her children for three years, but in savage Fiji it was a religious custom, and the taboo was placed on the mother in order to prevent the interference of the father. The prevalence of rickets among negroes may be due to the fact that the mother's diet of corn bread and fat pork is deficient in antirachitic vitamine. The British Committee base their statements concerning rickets on the experiments of Mellanby on pups. Hess and Unger failed to cure rickety babies on cream, but did so on cod-liver oil.

Xeropthalmia, keratomalacia or *xerosis conjunctivæ infantum*, an eye disease of infants that has been especially prevalent in the Scandinavian and other European countries during the war, is due to lack of antirachitic vitamine, the deficiency probably being greater than that required to produce rickets. It is accompanied by diarrhea. Sztark cites a case that developed after an exclusive diet of pea soup for fifteen months, and was cured in ten days on a diet of cows' milk.

Infantile beriberi occurs in infants nursing from mothers who have the disease, and whose milk is consequently deficient in antineuritic vitamine.

Infantile scurvy is due to deficiency of antiscorbutic vitamine. To quote again from "previtamine literature" Miller states that the opinion most commonly held is that scurvy is caused by a diet which through sterilization has been deprived of its "fresh element" and recommends orange and grape juice in its treatment. The fact that scurvy may occur in breast-fed infants, indicates variations in the antiscorbutic content of milk.

Marasmus is often considered a dietetic disease. Miller states that not seldom the child has thrived on the breast for a month or two, and has then been weaned in order that the mother may go out to work, and from that time has gradually wasted. Eddy and

Roper claim that the addition of a powder rich in vitamines to the cereal food of marasmic babies increased tissue growth. Vitamines are certainly necessary for growth, but so are other food constituents.

Since the question of growth has been referred to, perhaps it is well to remember that for normal growth there is necessary not only vitamines, but also the secretions of ductless glands. It is well-known that the size of the ductless glands is greatly affected in deficiency diseases in man and animals. According to McCarrison, deficiency of vitamines in the diet leads to abnormalities in the secretion of the ductless glands. We know that iodin in the food is necessary for the normal functioning of the thyroid, and it is possible to imagine unknown constituents of the diet that may be necessary for the ductless glands.

Pellagra may occur in breast-fed infants whose mothers have the disease, but it usually takes a long time to develop.

Deficiency diseases of adults may be different from those of infants, because growth is complete, although many of these diseases characteristic of adults occur also during adolescence or infancy.

War edema, also called famine edema or hunger edema, has been ascribed to lack of the antirachitic or fat-soluble vitamine, or other element in the diet. The fat content of the diet in war edema is not accurately known, but Guillermin and Guyot state that the total ration was sometimes as low as 800 calories, and it contained a very small proportion of fat, and that a decrease of 40 per cent. in body weight was common. Park has shown that it is readily cured by a return to the normal diet. War edema, or famine edema, as it is more often called, is not a new disease. Lusk refers to an account of it in France in 1817, just 100 years previous to the late outbreak in Germany and other European countries and Mexico. He also states that cases were cured in a week by the addition of 100 grams of fat to the ration. It is stated that edema occurs when there is a decrease in blood-plasma proteins, and hence that decrease in protein in the diet may cause edema. A diet of 800 calories fed prisoners is naturally deficient in protein. The scorbutic symptoms observed by Beyerman in famine edema suggest scurvy or a complication of scurvy. He states that the edema was cured by adding vegetables to the diet. Edema occurs in various deficiency diseases, and hence some confusion may arise in the classification, but the large number of cases of war edema that have occurred recently, indicate that it is a separate disease. Schittenhelm and Schlecht observed decrease in blood proteins in war edema.

Beriberi is a form of multiple peripheral neuritis caused by a deficiency of antineuritic vitamine, and is most prevalent in rice-eating countries. Wet beriberi is accompanied by edema, but in dry beriberi this is substituted by atrophy. As is often the case in deficiency diseases, there may be gastro-intestinal disturbances. The principal cause is too exclusive a diet of polished rice, and according to Fraser and Stanton, the substitution of undermilled rice, containing at least 0.4 per cent. of phosphorus, prevents the disease. It may be caused by too free use of any degerminated cereal. The addition of canned goods to the diet may not prevent it. There is apparently not enough yeast in bread to prevent beriberi. Beans and peas are perhaps the most useful preventives. In the treatment of the disease, extract of rice-polishings and fresh yeast or autolyzed yeast have been used. Funk, Lyle, McCoskey, Caspe and Poklop observed a mild glycosuria in man on a diet of white bread and polished rice.

Scurvy was perhaps the first deficiency disease to be recognized as such. Captain Cook showed that it could be prevented by the use of fresh vegetables. Nansen and Johansen passed a winter on an exclusive meat and fat diet without scurvy. Stefansson claims to have cured cases of scurvy by a raw meat diet. Apparently all fresh foods have traces of antiscorbutic vitamine. The juice of sweet limes or lemons is especially rich in this vitamine, and this fact has led to the development of a large industry for bottling lime juice. This preparation was not tested until recently, and was then found to be deficient. By some mistake, sour limes have been substituted for the curative sweet limes, and the lime juice of commerce does not come up to expectations.

Pellagra was called alpine scurvy by Italians, and has been shown by Goldberger to be a deficiency disease. By definition the disease is characterized by a symmetrical dermatitis, especially of those parts exposed to the sun, but this is not its most serious characteristic. The worst features of beriberi, scurvy and pellagra are the effects on the nervous system. The hemorrhages in pellagra are in the nervous system, whereas in scurvy they are general (and may occur in the meninges). Sundwall has shown that the tissue changes in pellagra are not specific, but are similar to those in animals on inadequate diets. In beriberi, pellagra and scurvy gastro-intestinal disorders are present. In pellagra edema is extremely localized, in scurvy it is associated with hemorrhage and in wet beriberi it is more general. Pellagra is of very wide distribution and may be worldwide. Since a patient with pellagra may live ten years, it is probably not due to complete absence of any dietetic constituent but to a slight deficiency. Whether this is a vitamine or an amino-acid, or both, has not been determined.

Trench foot is attributed by Bruntz and Spillmann to lack of vitamines associated with life in the trenches, the predisposing cause being the diet, and the water-filled trenches causing the acute symptoms in the feet.

Sprue was classed as a deficiency disease by Cantlie, who found scurvy in some cases. Brown states: "In the open alluvial workings of a tin mine in the East Indies all of the employes are exposed to the same atmospheric conditions. The Chinese coolie is stricken with beriberi, his European overseer with sprue. In no essential condition, even in that of diet, are the circumstances of their daily life materially different. The treatment of sprue is essentially dietary. A milk diet, a raw fruit diet, a milk and fruit diet or a raw or rare meat diet is used. In any case the diet contains vitamines."

VITAMINES AND APPETITE. In all animal experiments on a vitamine-deficient diet loss of appetite occurs. With human beings, psychological factors may enter in so as to make it difficult to perform clean-cut experiments on this subject, yet the final loss in tissue substance in all deficiency diseases suggests that the appetite has been affected. We know that pure proteins, fats and starches have no taste, but we do not know whether vitamines have flavor. We do know, however, that the taste of milk changes on boiling and the taste of many foods changes by canning or drying. Why is it that some persons have been known to defy the cholera germ for a raw oyster and the typhoid germ for a salad, and to give their lives for a momentary tickling of the palate? There must be some great advantage in fresh foods or else the desire for them would be eliminated by natural selection. To the clothes-moth the age of food seems to make little difference, but when a man sits down to a meal of storage eggs, canned milk, jerked beef and hardtack it requires considerable hunger to whet the appetite. This craving for fresh food has probably saved more lives than are killed by germs. The human race has existed for some time prior to the advent of food chemistry, and most people live nowadays without the aid of that science. Unquestionably the appetite has played some part in the preservation of the race. It seems probable that the person who is presented with an adequate choice of natural foods from infancy will choose an adequate diet, and that the cause of the deficiency diseases is that an adequate choice of foods is not always supplied to the table. In the case of animals this question has been tested. Evvard allowed pigs free choice among a variety of foods, and in this way produced the largest pig for its age that was ever raised at the Iowa Experiment Station. A more rigorous experiment was made by Osborne and Mendel, since they did not use natural foods but purified components made into a biscuit. A rat presented with a more and a less adequate biscuit might eat for a few days from the less adequate, but finally showed preference to the more adequate diet. These experiments did not refer to vitamines exclusively, but they show that an inadequate diet results in some change in the appetite.

FOOD SUBSTITUTION. According to Steenbock, fat-soluble-A is more abundant in yellow foods than in corresponding white ones. Yellow corn contained more than white corn, yellow oleo oil more than white fat separated from the same adipose tissue, yellow sweet potatoes more than white potatoes. The artificial coloring of butter may therefore deceive us as to its vitamine content. Without doubt the operation of the Pure Food and Drugs Act and the work of the laboratories operating under this law have been of inestimable advantage to the public. Food chemistry has not reached a sufficient stage of development to be relied on exclusively in questions of food substitution. Feeding tests are necessary, and the preference of the public for natural products, on which feeding tests have been made by the human race, is well grounded. The work of food fakirs has been insidious. Take the question of oleomargarin. The early products coming under this label in this country contained a large percentage of oleo oil, which is rich in the fat-soluble vitamine. Little by little the proportion of such oleomargarins has decreased and perhaps the majority of oleomargarins today are made from cottonseed and cocoanut oils and are deficient in fat-soluble vitamine. Galicians eat lard on their bread, but it is said that the black bread they use contains some fat-soluble vitamine from the rye germ. Negroes have a particular fondness for pork fat and white cornmeal bread, and this may be the chief cause of the prevalence of rickets in negro babies, since the diet of the mother does not contain enough fat-soluble vitamine to be transmitted to the milk. In a milk-canning factory in this country, skimmed milk and vegetable oils were run through a homogenizer and canned as milk compound. The cook may see the label on the artificial milk or butter, but the defenceless boarder does not even have the satisfaction of reading his sentence. Another deception is the soaking of dried green peas in water and then canning them. The Pure Food and Drugs Act does not allow the picture of a peavine to be placed on these cans, but the average consumer is not familiar with such distinctions in labels.

In natural foods a sweet taste is associated with fruits that are rich in antiscorbutic vitamines. If we may suppose that the taste for sweets is inherited, our savage ancestors may have eaten raw fruits, just as the monkeys in the jungle do nowadays. Most of the sweet food and drinks of modern man are made from sugars and molasses and honey that are free from vitamines. Coffee and its substitutes and tea, malted or distilled liquors, wines and carbonated drinks with synthetic flavors are deficient in vitamines.

I ordered a meal in a "pure food restaurant" and received various fake dishes, including an imitation beafsteak made of degerminated cereals. The fact that we use milk with cereals is probably what saves us from disaster. One is reminded of the old story of the soup-stone: A man knocked at the kitchen door and said he was introducing soup-stones. The stone was to be boiled in water, and he demonstrated it to the housewife, suggesting various ingredients that might be added to it. These were promptly produced by the enthusiastic housewife and the man drank the soup, leaving her the stone. Cereals form the basis of our diet, but scurvy develops when they are used as substitutes for potatoes or other vegetables, as occurred in Glasgow, Newcastle and other cities during a potato shortage during the war. In one institution in the United States there were 200 cases of scurvy on April 1, 1916, following two months' reduction of the potato and other vegetable ration to one-half.

THE MILK QUESTION. The rise in the cost of living, more than the rise in the cost of milk in particular, has led to a reduction in the consumption of milk by families with small incomes. Harris records data from 2084 families, representing in nationality and income a typical cross-section of New York City in the summer of 1918. In 14 per cent. of these families milk was entirely eliminated from the children's dietary. McCollum has repeatedly emphasized the advantage of milk in the diet. Mendenhall states that every child from eighteen months to twelve years of age is better for having one and a half pints of milk in its daily diet, and that fluctuations in the demand for milk or diminished use of milk throughout the country will inevitably result in a lessened production, and that the loss of our herds at this critical period would be a calamity. Hart and Steenbock call attention to the use of milk as a supplement to cereal foods. Milk makes up the deficiency of cereals in vitamines, salts and certain amino-acids of the proteins. The United States Food Administration calls attention to the fact that milk compares favorably with other animal foods in price per gram of protein and in price per calorie, and that there is only enough milk consumed in this country to give each person a little more than half a pint per day. Twenty and more years ago a professor of mathematics used to tell a story of being hard up in his college days. He calculated that he would have ten cents a day to spend for food, and that the highest nutritive value could be gotten from ten cents' worth of milk. Practical experience, however, suggested a change to five cents' worth of milk for nourishment and five cents' worth of mince pie to "stay with" him.

The chief value of milk lies in the fact that it is a complete food and does not require any balancing of components or any precautions to include the minimum requirement of any constituent. I have never found a species of cooks who would calculate or weigh or balance any food constituents except under immediate compulsion. With a milk diet for the infant and a modicum of milk in the diet at all other ages the expense of calculation of dietary constituents is eliminated, and milk even at a high price may be worth buying in order to avert the danger of malnutrition and doctors' bills or loss of efficiency. It is an open question, however, whether cows' milk has been beneficial to infants in general. During the famine resulting from the siege of Paris the infant mortality fell 40 per cent., due to the fact that mothers nursed their own infants. A similar decrease occurred during the great Lancaster cotton famine, due to the fact that the mothers could not work in the factories and did not have the money to buy cows' milk for the infants. During the recent occupation of Lille by the Germans, when the adult population lost about 40 per cent. in weight, there was a reduction in infant mortality, due to the fact that the mothers nursed their own infants. In the absence of mothers' milk, however, cows' milk is the best food for infants, but it is better to feed the cows' milk to the mother if she can nurse her child.

ARMY RATIONING. It seems probable that the chief point of attack of faulty nutrition on the military strength of a nation is on the infant males. Crooked bones, bad teeth and other deficiencies may result from faulty feeding of prospective soldiers. If the soldier going into action has a well-nourished body to begin with a short campaign on very defective rations may not lead to serious consequences. The protein, fat, mineral salts and vitamines stored in the body may be drawn on to make up the deficiency. It is often stated that the body cannot store protein, and it is true that protein is not stored in the same way that fat is; but the protein of the muscles may be drawn on for a considerable period, as has been the case in millions of persons during this war.

The ration allowed the army by Congress has been subject to many variations. The soldier eats what he can get, but must necessarily be influenced by the ration allowance. During the Revolutionary War conditions were very variable. In 1780 the American Army was increased by the addition of the French Division (5000 men), who landed from transports with over 600 cases of scurvy among the soldiers and 1000 cases among the sailors after a voyage of two months and nine days.

In 1775 fresh milk was included in the army ration, but since it could not always be supplied a revision of the ration was soon necessary. In 1798 Congress fixed the ration at 20 ounces of beef, 18 ounces of bread and an allowance of salt, soap and candles. Food profiteers made a liberal interpretation of the words "bread and beef," so that the Surgeon-General thought it necessary to report unfavorably on the results. The two staple articles of the ration have remained practically unaltered in quantity until the present day, but later Congresses allowed liquor and specified substitutes for beef. In 1818 the President was authorized to make changes in the ration other than increase in cost, and in 1834 he substituted coffee and sugar for the liquor component. Temporary increases for the period of the Civil War were made, but except when raids were made on food stores the nutrition of the troops was not ideal. Owing to the large proportion of preserved food, including flour, salt meat, desiccated vegetables, canned milk and coffee extract, 30,741 cases of scurvy were recorded among white troops. In 1890 a pound of fresh vegetables was added to the ration and in 1908 the present garrison ration was authorized, which is of sufficient cost and allows sufficient substitution to furnish an adequate diet. The savings privilege in rationing in garrison, authorized in 1910, was abused to such an extent that it was discontinued April 1, 1919, and all substitutes are purchased through the quartermaster and the savings revert to the Government.

About the only data we have of the nutritive balance of our soldiers are their weight records. According to Munson the average peace-time recruit gains about 2.8 pounds in the first three and a half months of military service. Similar figures for the National Army, compiled by Hildebrandt, show a gain of 6.4 pounds in the first four months of military service. The total gain during the war has been reported as twelve pounds per man. Such figures are encouraging, considering the fact that some of the recruits were undernourished at the time of enlistment. If the added weight is not necessary for muscular strenght it is useful in raising the resistance to disease and famine. The army has experimented with an emergency ration, consisting of a dried mass of chocolate, eggs, milk and sugar that has a high protein and calorific value, but no one has been able to eat it for more than three successive days. When water only is available a reduction of a pound a day in body weight occurs in warm weather and more as the weather turns colder, and a few pounds excess body weight form the best emergency ration, since accidental loss is eliminated. Owing to the fact, however, that carbohydrate is stored to a very limited extent in the body, the use of hardtack, if available, is advantageous.

I have had opportunity to compute the protein, fat, carbohydrate and total calories per man per day in a large number of army messes and have studied the data compiled by the Food Division, and in the majority of the few cases of deficiency noted, have found that the mess sergeant was inaccurate in his accounts or was trying to produce an impression on the inspectors. In some cases the soldiers and their mess officers complained of the food. The chief ground of complaint was that there was not a sufficiency of fresh fruit and vegetables. I computed the mineral constituents, and especially the acid-base balance, of these messes, and found them usually acid. Certain foods, however, which yield a basic ash (dried beans, for instance) were served too frequently to please the soldiers. It was not the character of the ash of the food which influenced their comment, but its freshness. Certain national guard companies had company funds sent them from their home towns. I found some of these companies at Camp Cody, N. M., spending thirty cents per man per day for fresh milk and a more variable sum for fresh California fruit. A certain officer having about 2200 men in his command found inefficiency in one or more of his mess sergeants and decided to run the messes himself. He made up bills of fare for twenty-one meals and ordered all mess sergeants in his command to use them. The foods listed were those carried by the quartermaster and there was a conspicuous absence of the fresh fruits and vegetables of the local markets. I found the order to use the menu evaded more frequently the farther the mess was from headquarters, and at the end of ten days the scheme was abandoned. If the desires of the soldiers may be expressed in chemical terms, they desired vitamines, and especially antiscorbutic vitamines.

Whereas the ration allowance for soldiers on duty has been based on the price of food, and the same was originally allowed for sick soldiers, during a certain period each base hospital was allowed a fixed sum of money for each sick soldier on its rolls. On June 1, 1918, the ration allowance for a sick soldier was fixed at fifty cents. In some of the larger hospitals savings were made, but the smaller hospitals reported that the allowance was not sufficient. I have no records for the same hospital covering a long period, but by combining data from three hospitals some comparisons may be made. These data are from Camp Pike, Ark., June, 1918, Camp Cody, N. M., August, 1918, and Camp Fremont, Cal., November, 1918. During this period there was a general rise in the cost of food, and to meet this, reductions in the higher priced articles of food were made. In June 13 ounces of fresh meat per ration were served, in August 7 ounces and in November only 3.2 ounces. In June 2.5 eggs per ration were served, in August 1.2 and in November 0.4. At Camp Fremont from August 1 to September 1 the rise in price of fresh eggs was from 52 to 89 cents per dozen, of fresh milk from 23 to 40 cents a gallon and of oranges from 6 to 13 dollars a crate. At the end of this period the fixed allowance was superseded by a sliding scale system based on the local cost of the garrison ration plus a certain percentage that was greater the smaller the hospital.

The above remarks apply to the army in this country, but the United States troops in other countries have not always fared so well. Beriberi among the Philippine scouts gave occasion for an order that the meat ration was to be eaten and that the rice was to be undermilled (Chamberlain). Riddell, Smith and Gutierrez reported 60 cases of beriberi in the United States Army in Porto Rico November, 1918. Potatoes, beans and canned meats and vegetables were supplied the troops, and these data led to the supposition that the reduction in vitamine by canning may have been a factor.

The fly problem is serious in the army. Ball has shown that the house-fly may be carried 100 miles by the wind. I have seen squads of soldiers swatting flies in mess halls when the civil authorities allowed a mountain of horse manure to remain two miles outside of camp.

Discussion. Observations, some of which are reported in this paper, have led me to believe that the nutrition of some individuals, especially infants, is not ideal, and that the high cost of living is leading to worse nutrition. A large part of the population has unconsciously depended on the presence of milk in an otherwise inadequate diet, and the decrease in milk consumption that is now taking place is to be viewed with alarm. The supply of fresh green vegetables is not sufficient to be a substitute for milk. Grass is not adapted to human alimentation except in the form of sprouted grass seeds. In the sprouting of seeds vitamines are syntheized in the young leaves and a quick crop of vitamines may be obtained without the necessity of planting the seeds in the ground. McClendon, Cole, Engstrand and Middlekauff have most recently studied the question of sprouting cereal grains. Wheat or rye, sprouted until the shoot extends an inch beyond the grain and heated in water to 70° to gelatinize the starch, forms a cheap and convenient and palatable source of vitamines. The seeds may be freed from bacteria before sprouting (Braun and Duggar and Davis). Since beef fat is about as valuable a source of vitamine as butter is, beef drippings and fat should be eaten rather than thrown in the garbage can, and the same applies to some other animal fats. Prolonged cooking of fresh foods should be discouraged, but all canned goods should be heated to boiling before serving, in order to destroy toxins of Bacillus botulinus that might be present, unless a competent inspection of the goods has been made.

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THE CURE OF HOOKWORM INFECTION.[1]

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During the recent war there were admitted to the author's gastro-intestinal service at the United States Army General Hospital No. 14, Fort Oglethorpe, Georgia, 393 cases of ankylostomiasis, over one-fourth of which had received previous and obviously unsuccessful hookworm treatment. This large proportion of failures is due, in our opinion, (1) to the real difficulty of achieving a complete cure quickly by the methods of treatment heretofore in vogue, and (2) to the lack of sufficient observation after treatment, owing in turn to the absence of satisfactory scientific data on which the precise criteria of cure could be based. It has been our endeavor to remedy both these defects, the former by the development of the intra-intestinal tube treatment already described[2] and the latter by means of the most intensive studies of the results of therapy that we could possibly make under army conditions.[3]

As soon as a hookworm suspect was admitted to our service, and before any treatment was given, stools were sent daily to the laboratory until the diagnosis was confirmed beyond question. After treatment, specimens were similarly examined, every other day, as a rule, until an interval of twenty-eight days had elapsed, unless they were reported positive before that. For the purpose of compiling the statistics presented in this paper, all incomplete observations have been entirely discarded. Our conclusions, accordingly, are based on 231 cases, all of which were observed twenty-nine days or over (up to two hundred and twenty-eight

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[1] Read before the Duval County Medical Society, Jacksonville, Fla., Oct. 28, 1919.

[2] Kantor, J. L.: The Intra-intestinal Tube Treatment of Hookworm Infection, Jour. Am. Med. Assn., 1919, vol. lxxiii, 1181.

[3] At the time this work was carried on, Lieut.-Col. Calvin D. Cowles, Jr., of the regular army, was in command of the hospital. Dr. Lewis C. Ecker, of Washington, D. C., was in charge of the medical service. Drs. Burrill, Dunning, Paul, Hill, Hughes, Swan, Hagler, Rudbeck and Mahoney were at various times associated with the gastro-intestinal section. Dr. Le Roy Smith was in charge of the laboratory. The actual stool examinations, a task of great magnitude, were very capably performed by Mr. E. A. Piper.